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Final Technical Report: Brief Summary  
Comparison of TOMS and AVHRR Imagery of Volcanic Clouds..  
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Initial studies of merging of Volcanic Cloud data from the TOMS and AVHRR sensors were made in this project. Because the data are acquired from different satellite platforms, and have totally separate processing algorithms and formats, their combination and registration required considerable specialized effort.

After perfecting the techniques of registration we studied several eruptions where there was data from both sensors. The results were communicated in presentations (1,2) and a master's thesis was completed (3), which was in turn converted into a paper to be submitted to the Journal of Geophysical Research (4).

Our conclusion from initial work shows that the positions of the volcanic clouds as detected by the two sensors is very similar. Because our AVHRR algorithm is now capable of retrieving masses of ash and sulfate aerosol, the capability of comparing data from the two sensors now allows us to describe changes in SO<sub>2</sub>, H<sub>2</sub>SO<sub>4</sub> and silicate ash in drifting volcanic clouds.

(1) Hossli, R., W. I. Rose, D. J. Schneider and I. Sprod, 1993, Simultaneous use of AVHRR and TOMS for remote sensing of Volcanic clouds, *AGU Fall Meeting Abstracts* (abstract attached).

(2) Schneider, D. J. and W. Rose, 1993, AVHRR observations of the volcanic ash cloud from Pinatubo Volcano, *FAA workshop on Old Volcanic Clouds*, April 22-23, 1993, Washington, DC (abstract attached).

(3) Hossli, R., 1994, Simultaneous tracking of volcanic clouds using AVHRR and TOMS satellite imagery, *unpubl. MS thesis*, Michigan Technological University, 45pp.

(4) Hossli, R., W. I. Rose, I. Sprod and G. Bluth, in prep, Simultaneous tracking of volcanic clouds using AVHRR and TOMS, to be submitted to *JGR*.

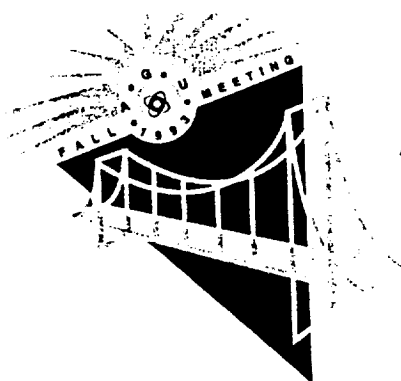
## **Simultaneous Use of AVHRR and TOMS for Remote Sensing of Volcanic Clouds**

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We have undertaken registry and comparison of contemporaneous data from two separate sensors on separate satellites for several recent volcanic eruptions. To allow for mapping and gridding, we injected already mapped and processed TOMS data from Goddard into the software we use in processing AVHRR (Terascan). We selected AVHRR swaths that matched as closely as possible the times of TOMS data collection. Most comparisons are within a few hours, and one pair of images is separated by only 6 minutes. We have now completed comparison of AVHRR and TOMS for several days following four recent eruptions: Pinatubo, June 1991; Hudson, August 1991; Crater Peak/Spurr, August and September 1991.

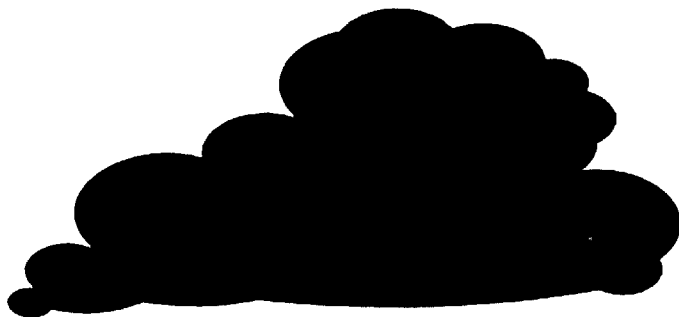
In general the two sensors, although they detect different things (AVHRR: ash; TOMS:  $\text{SO}_2$ ), detect volcanic clouds that are similar in size. The AVHRR and TOMS portraits of volcanic clouds describe cloud movements that are remarkably similar. One set of images of Crater Peak/Spurr cloud separated by only 6 minutes was examined in detail: there is a very high spatial correlation of mapped pixel values using brightness temperature differences of band 4 and band 5 (AVHRR) with  $\text{SO}_2$ , in Dobson units (TOMS). These observations strongly suggest that  $\text{SO}_2$  and fine ash move together for long distances in drifting volcanic clouds. Both signals decay over a time period of several days. The AVHRR signal is lost in some cases when high clouds underlie the volcanic cloud. We aim to compare ash and  $\text{SO}_2$  burdens in succession for each eruption to measure dispersion and cloud evolution processes.



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# FEDERAL AVIATION ADMINISTRATION

## WORKSHOP ON OLD VOLCANIC ASH CLOUDS



WASHINGTON, D.C.

APRIL 22-23, 1993

### AVHRR OBSERVATIONS OF THE VOLCANIC ASH CLOUD FROM PINATUBO VOLCANO

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The June 15, 1991, eruption of Pinatubo Volcano produced a large ash cloud which drifted for thousands of kilometers. Casadevall (*Aviation Safety Journal*, v. 3, no.2, pp.3-11) reported that 17 commercial aircraft were damaged by in-flight encounters with ash from Pinatubo, and that world-wide, more than 50 aircraft have been damaged by encounters over the past 12 years. Satellite observations of volcanic clouds have the potential to reduce these dangerous and costly encounters. More than 20 Advanced Very High Resolution Radiometer (AVHRR) images between June 12 and June 20, 1991 have been analyzed. Volcanic clouds were successfully discriminated from meteorological clouds in the images by calculating an AVHRR band 4-minus-band-5 temperature difference. From June 12 to June 16, the boundaries of the volcanic clouds as discriminated by the band-4-minus-5 operation were correlated to cold clouds observed in band 4-images, such as those now used routinely in meteorological analyses. However, by June 17, the boundary of the volcanic cloud could not be identified in the band 4-images. Because the main mass of volcanic material was transported in the stratosphere, its movement is unrelated to the movement of tropospheric clouds. In cases like these, multispectral image processing is the only way to determine the boundaries of the volcanic cloud. The magnitude of the band-4-minus-5 volcanic-ash signal declined over time, possibly due to the fallout of ash particles and the dispersal of the cloud. We hope to invert the bispectral AVHRR data to estimate particle size and concentration.